CALIBRATION RESULTS FOR J-ERS-1 SAR DATA PRODUCED BY THE ALASKA SAR FACILITY

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ABSTRACT

The Alaska SAR Facility has been receiving and processing SAR data from the J-ERS-1 satellite since Spring 1992. Comer reflectors have been set up for J-ERS-1 SAR calibration at a site near Delta Junction, in central Alaska. Image quality and calibration analysis results from the Delta Junction site and others will be presented in this paper.

The impact of the 3-bit Analog-to-Digital Converter and the automatic stepping of the gain as a function of range in the J-ERS-1 radar receiver on calibration performance has been assessed.

Preliminary observations on J-ERS-1 SAR data are that the average Signal-to-Noise ratio is generally fairly low, in the range 5-6dB. Azimuth ambiguity levels are higher than preflight analysis indicated. Over land, the dynamic range in the backscatter at L-band for -36 degree incidence angle is often fairly high. Thus example J-ERS-1 SAR images of vegetated areas, such as tropical rain forests or boreal forests show greater contrast than their counterparts from the European ERS-1, which images at C-band with -23 degree incidence angle.

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SUMMARY

Initial analysis of Alaska SAR Facility (ASF) J-ERS-1 SAR data suggested that there was a problem with the azimuth focusing algorithm, the measured range resolution is nominal and the data is essentially radiometrically calibrated, with a calibration constant of -49 dB plus or minus 1.5 dB. The azimuth focusing problem has since been remedied. Measurements indicate signal to noise ratios (SNR) which are significantly lower than the corresponding values presented in the CEOS header files, and SAR stability studies indicate the possibility of a gain variation between data takes.

INTRODKJCTION

This is a first report of results from the calibration work conducted on the J-ERS-1SAR. The data used for the analysis were processed at ASF and presented in unsigned byte amplitude format. Full resolution four look image products from data takes over the Delta Junction calibration site in Alaska were used for calibration and impulse response analysis. Low resolution image products from data takes over Delta Junction, the Arctic Ocean and distributed targets in the Amazon were used for the evaluation of the radiometric correction. Since image products used are in byte amplitude format (which has a dynamic range on the order of 48 dB), the signatures of corner reflectors tend to saturate, giving pixel values of 255. To avoid the problem of lost information due to saturation, data processed at lower gain was used for the calibration and impulse response analysis. The analysis of raw data was used to determine how to correct for the automatic stepping of the gain as a function of range prior to quantization.

IMPACT OF SF; NSITIVITY TIME CONTROL ON CALIBRATION PERFORMANCE

In order to increase the dynamic range of the J-ERS-1 SAR, before the 3-bit quantization process the received signal is attenuated in such a way as to follow the inverse of the across track antenna pattern with 1 dB steps by what is known as the Sensitivity Time Control (STC). Step size simulation and analysis of raw J-ERS-1 SAR data has shown step size variation with varying signal levels, and has been used to determine how to compensate for the STC steps during processing. Currently the STC correction step size used is 0.6 dB, which is appropriate for signals near the ADC saturation region.

CALIBRATION ANALYSIS

The calibration analysis was performed using 'disa' (display image/statistical analysis), a software package designed by Rob Fatland of JPL. Jason Williams of ASF and Marcos Alves of JPL also made contributions to the software. In this first stage of calibration, images of the Delta Junction calibration site for five different passes were used. Table 1 shows the calibration constant, K, obtained from the analysis of the return from the 8 foot trihedral corner reflectors oriented towards J-ERS-1 (DJ3 and DJ7) present in each image. In this table, G is the processor gain for the given image and $a1$ is pulled from the image leader file and added to G so as to obtain a leader file K value (determined by Tom Bicknell of JPL through analysis of sea ice data).

The K values obtained from DJ3 arc about -49 dB plus or minus 1.5 dB, which is reasonably consistent with the

Image ID	rev	Overfight year day:hr	G (dB)	DJ3 K (dB)	DJ7 K (dB)	al+G (dB)
1000346	2528	'92 210:20	-12	-48.32	-45.97	-48.54
1000348	3816	'92 296:20	-12	-49.10	------	-48.54
1000350	3831	'92 297:20	-12	-4994	------	-48.54
1000353	3861	'92 299:20	-12	------	-47.84	-48.54
1000355	3876	'92 300:20	-12	------	-47.62	-48,54

Table 1

corresponding leader file value of -48.54 dB. DJ7 K values are slightly higher due to a lower return from this reflector. This may be a result of, among other possibilities, the presence of debris (snow or ice) on the reflector surfaces.

In order to gauge the stability of the SAR, four 250,000 pixel areas were chosen for comparison between images, each image corresponding to a distinct pass over Delta Junction. The normalized radar cross section was found for the areas present in each image, and are presented (in dBm^2) in Table 2.

Image ->	1000346	1000348	1000350	1000353	1000355	dif
'92 Date->	7129	9/23	9/24	9/26	9}27	
Area 1 ->	-8.16	......	-11.01	-------	.....	2.85
Area 2 ->	------	-10.88	-11.13	......	......	0.25
Area 3 ->	-9.18	....		-9.65	......	0.47
Area 4 ->	------	------	------	-9.74	-8.33	1.41

'l'able 2 - Sigma O values (dB) for different areas

Some of the difference between measurements of the same area can be accounted for by natural variations in reflectivity within the scene, however the differences that appear for areas I and 4 are fairly large. It may be that a gain factor problem has not been identified and addressed in the processing of the images. SNR measurements were obtained for two full resolution normal gain Delta Junction images by using dark regions on the images (lakes, mountain shadows) to estimate the noise level and the average power of an entire image as the signal plus noise level. For images 1001151 and 1001223, SNR's were found to be 7.5 dB and 8.1 dB respectively, with an estimated error of 0.46 dB assuming the noise power in the full resolution image data has a chi-squared distribution with four degrees of freedom (i.e. four looks). Comparison of these measurements to the SNR presented in the header files (13.3 dB and 13.1 dB, respectively) indicates that tbe header values are very optimistic, and should not be taken for their face value. For these images where the noise equivalent sigma zero (NES0) at the center of the swath sre -21.7 dB and -21.0 dB according to the header, the measurements would -13.5 dB and -12.3 dB be respectively. It is possible that some default from E-ERS-1 has not been changed for the J-ERS-1 data, or simply that the noise floor used to calculate the header SNR is too low.

'f'he number of looks was evaluated for the same two images used for SNR measurements by plotting histograms of the mean squared over variance (which corresponds to number of looks) of 7 by 7 pixel boxes. The histograms are presented in Figure 1 in support of the fact that these arc in fact four look images, with the peak number of looks at 3.6.

IMPULSE RESPONSE ANALYSIS

The impulse response analysis was also performed using 'disa' and the full resolution Delta Junction images mentioned above. Table 3 shows the results of this analysis.

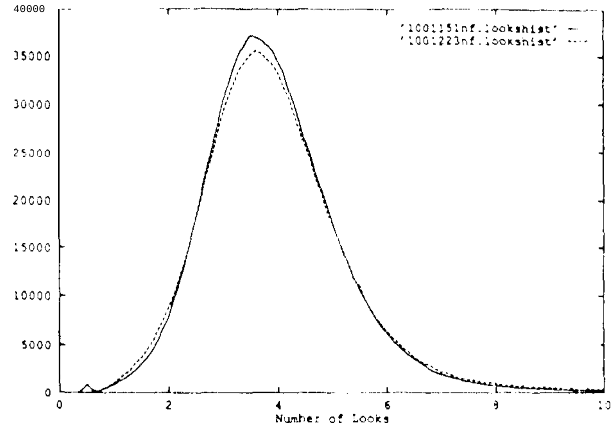

Figure 1

Image	CR	inc ang (deg)	slant rng (km)	rng res (m)	az res (m)	rng PSLR (dB)	az PSLR (dB)
1000346	DJ3	37.73	716.85	19.53	34.77	-542	-11.60
1000346	DJ7	40.91	745.83	17.19	31.25	-867	-1235
1000348	DJ3	41.22	748.42	17.97	3594	-6.78	-16.58
1000350	DJ3	39.47	731.82	17.19	26.95	-10.48	-13.48
1000353	DJ7	38.97	727.79	17.19	28.S2	-9.96	-14.43
1000355	DJ7	37.05	711.43	19.14	35.16	-7.86	-16.57

Table 3

The J-ERS-1 resolution requirements are 18 m in range and 28 m in azimuth (for four look data and present weighting for sidelobe suppression). The analysis shows range resolution averaging at 18 m, while azimuth resolution is not ideal at 32 m, yet seems reasonable at first, However, the azimuth resolution is high at near range, then drops off to the nominal value before rising again at far range. This dependence of the azimuth resolution on range first observed by Jason Williams of ASF and supported by the results shown here indicate poor focusing of the data. This has a significant effect on the PSLR measurements since the peak value decreases as the energy is spread out in azimuth, rendering them an unreliable measure of data quality at the present time. Since the focusing problem does not cause energy from the backscatter to be lost, and the method for calculating the calibration constant K involves averaging energy over many pixels (for both peak and background returns), [he K values obtained are not seriously effected so and can be considered reliable.

EVALUATION OF RADIOMETRIC CORRECTION

For the evaluation of radiometric correction, portions of several images' RCS were averaged along the range direction. The resulting plots are presented in Figure 2, Figure 3 and Figure 4. No unexpected trends were found in the analysis of the mountainous regions of Delta Juction that would indicate poor radiometric correction (the standard deviation of the points in each plot was 0.6 dB). The same can be said for the sea ice data from the Arctic Ocean, although the RCS appears to drop off and then increase with range, The explanation for this, bowever, involves the fact that noise is flat before radio metric correction so that it reflects the shape of the radiometric correction vector in the image. Evidence of this shape in the ice data is therefore an

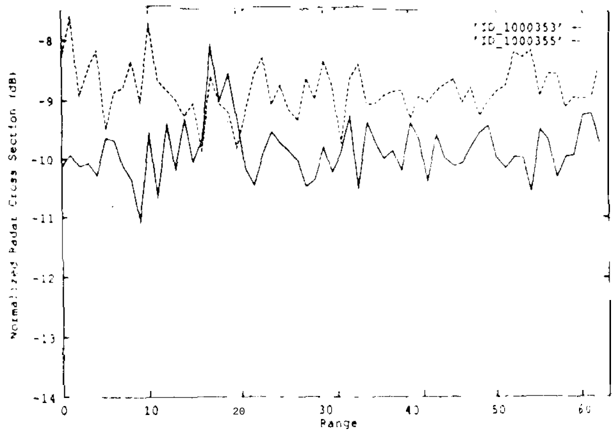

Figure 2 - Delta Junction Mountains

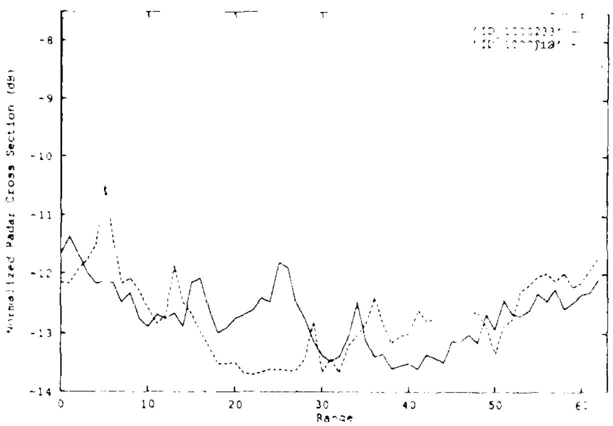

Figure 3 - Arctic Sea Ice

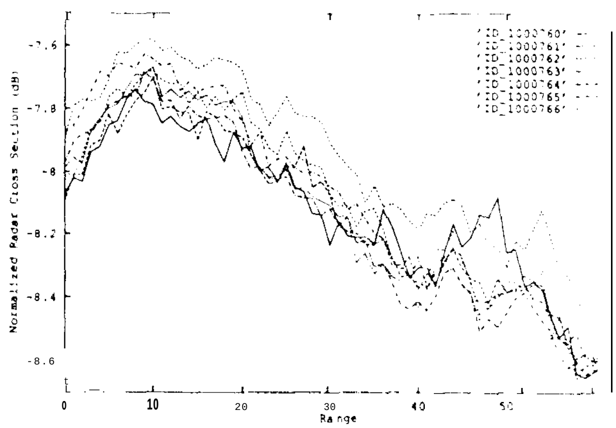

Figure 4 - Amazonian Rain Forest

indication of a low SNR. In addition, although the STC correction step size of 0.6 dB used is appropriate for returns near saturation of the ADC, the ice data returns are far below saturation causing STC steps to be greater in the raw data (on the order of 0.8 dB or 0.9 dB). Analysis of distributed target data in the Amazon, however, shows a definite trend in RCS variation across track. One explanation is that the correction for the antenna pattern is not properly aligned, resulting in a roll off in range of about 1 dB. The 1 dB roll off may also reflect the backscatter variation of the rainforest.

FUTURE

Currently, previously processed J-ERS-1 SAR data takes are being reprocessed and renumbered at ASF and will reflect the improvements resulting from processing parameters now available. Analysis of J-ERS-1 SAR data products will continue with analysis of newly processed images as they become available, and a comparison between AIRSAR and J-ERS-1 following the AIRSAR campaign scheduled for the middle of this year.